

CLAIMS

What is claimed is:

1. A method for treating a high dielectric layer of a semiconductor device, comprising:
nitriding a high dielectric layer on a silicon substrate, wherein said high dielectric layer comprises a nano laminate comprising a Group 3 metal oxide layer and a layer selected from the group consisting of a hafnium oxide layer and a zirconium oxide layer; and
post treating the high dielectric layer and silicon substrate.
2. The method of claim 1, wherein nitriding a high dielectric layer comprises nitriding said high dielectric layer using a nitriding process selected from the group consisting of a nitrogen plasma treatment process, a thermal treatment process in a nitrogen atmosphere, and a thermal treatment process comprising thermally treating the high dielectric layer after forming a nitrogen layer on the high dielectric layer.
3. The method of claim 1, wherein post treating the high dielectric layer and silicon substrate comprises post treating using a process selected from the group consisting of an oxidation process and an annealing process.
4. The method of claim 1, further comprising forming said high dielectric layer over a silicon substrate.
5. The method of claim 4, wherein forming said high dielectric layer over a silicon substrate comprises:
depositing a layer selected from the group consisting of a hafnium oxide layer and a zirconium oxide layer on the silicon substrate; and
depositing a Group 3 metal oxide layer over the layer.

6. The method of claim 5, wherein the Group 3 metal oxide layer is selected from the group consisting of aluminum oxide and yttrium oxide.

7. The method of claim 5, further comprising depositing an additional layer over the silicon substrate, the additional layer selected from the group consisting of a hafnium silicate layer, a zirconium silicate layer, and an aluminum silicate layer.

8. A method for treating a high dielectric layer of a semiconductor device, comprising:

nitriding a silicon substrate and a high dielectric layer on said silicon substrate, said high dielectric layer comprising at least one layer selected from the group consisting of a hafnium oxide layer, a zirconium oxide layer, and a Group 3 metal oxide layer; and

then annealing the silicon substrate and high dielectric layer.

9. The method of claim 8, wherein the Group 3 metal oxide layer is selected from the group consisting of an aluminum oxide layer and a yttrium oxide layer.

10. The method of claim 8, wherein the high dielectric layer further comprises at least one layer selected from the group consisting of a hafnium silicate layer, a zirconium silicate layer, and an aluminum silicate layer.

11. The method of claim 8, wherein said nitriding is performed using a nitriding process selected from the group consisting of a nitrogen plasma treatment process, a thermal treatment in a nitrogen atmosphere process, and a process comprising forming a nitrogen layer over the high dielectric layer and thermally treating the formed nitrogen layer.

12. The method of claim 8, wherein said annealing the silicon substrate and high dielectric layer comprises annealing the silicon substrate and high dielectric layer in an atmosphere selected from the group consisting of an inert gas atmosphere, a heavy hydrogen atmosphere, a hydrogen atmosphere, a mixed nitrogen and hydrogen gas atmosphere, and a vacuum atmosphere.

13. The method of claim 8, wherein said annealing the silicon substrate and high dielectric layer comprises annealing the silicon substrate and high dielectric layer at a temperature at or between about 750 °C and 1100 °C.

14. A method for treating a high dielectric layer of a semiconductor device, comprising:

nitriding a silicon substrate and a high dielectric layer on said silicon substrate, said high dielectric layer comprising at least one layer selected from the group consisting of a hafnium oxide layer, a zirconium oxide layer, and a Group 3 metal oxide layer; and
then oxidizing the silicon substrate and high dielectric layer.

15. The method of claim 14, wherein the Group 3 metal oxide layer is selected from the group consisting of an aluminum oxide layer and a yttrium oxide layer.

16. The method of claim 14, wherein the high dielectric layer further comprises at least one layer selected from the group consisting of a hafnium silicate layer, a zirconium silicate layer, and an aluminum silicate layer.

17. The method of claim 14, wherein said nitriding is performed using a nitriding process selected from the group consisting of a nitrogen plasma treatment process, a thermal treatment in a nitrogen atmosphere process, and a process comprising forming a nitrogen layer over the high dielectric layer and thermally treating the formed nitrogen layer.

18. The method of claim 14, wherein said oxidizing the silicon substrate and high dielectric layer comprises wet oxidizing the silicon substrate and high dielectric layer.

19. The method of claim 14, wherein said oxidizing the silicon substrate and high dielectric layer comprises dry oxidizing the silicon substrate and high dielectric layer.

20. The method of claim 14, wherein said oxidizing the silicon substrate and high dielectric layer comprises oxidizing the silicon substrate and high dielectric layer with an oxidizing agent selected from the group consisting of ozone, radical oxygen, and oxygen plasma.

21. A method for treating a high dielectric layer of a semiconductor device, comprising:

nitriding a silicon substrate and a high dielectric layer on said silicon substrate, said high dielectric layer comprising at least one layer selected from the group consisting of a hafnium oxide layer, a zirconium oxide layer, and a Group 3 metal oxide layer; and then
oxidizing the silicon substrate and high dielectric layer; and
annealing the nitrided and oxidized silicon substrate and high dielectric layer.

22. The method of claim 21, wherein the Group 3 metal oxide layer is selected from the group consisting of an aluminum oxide layer and a yttrium oxide layer.

23. The method of claim 21, wherein the high dielectric layer further comprises at least one layer selected from the group consisting of a hafnium silicate layer, a zirconium silicate layer, and an aluminum silicate layer.

24. The method of claim 21, wherein said nitriding is performed using a nitriding process selected from the group consisting of a nitrogen plasma treatment process, a thermal treatment in a nitrogen atmosphere process, and a process comprising forming a nitrogen layer over the high dielectric layer and thermally treating the formed nitrogen layer.

25. The method of claim 21, wherein said oxidizing the silicon substrate and high dielectric layer comprises wet oxidizing the silicon substrate and high dielectric layer.

26. The method of claim 21, wherein said oxidizing the silicon substrate and high dielectric layer comprises dry oxidizing the silicon substrate and high dielectric layer.

27. The method of claim 21, wherein said oxidizing the silicon substrate and high dielectric layer comprises oxidizing the silicon substrate and high dielectric layer with an oxidizing agent selected from the group consisting of ozone, radical oxygen, and oxygen plasma.

28. The method of claim 21, wherein said annealing the nitrided and oxidized silicon substrate and high dielectric layer comprises annealing the nitrided and oxidized silicon substrate and high dielectric layer in an atmosphere selected from the group consisting of an inert gas atmosphere, a heavy hydrogen atmosphere, a hydrogen atmosphere, a mixed nitrogen and hydrogen gas atmosphere, and a vacuum atmosphere.

29. The method of claim 21, wherein said annealing the nitrided and oxidized silicon substrate and high dielectric layer comprises annealing the nitrided and oxidized silicon substrate and high dielectric layer at a temperature at or between about 750 °C and 1100 °C.

30. The method of claim 21, wherein said oxidizing the silicon substrate and high dielectric layer comprises oxidizing the silicon substrate and high dielectric layer at or between a temperature of about 700 °C to about 900 °C.

31. A method for treating a high dielectric layer of an integrated circuit device, comprising nitriding to provide a nitride profile concentration in the high dielectric layer that is greater adjacent to the polysilicon/high dielectric layer interface than adjacent to a silicon/high dielectric layer interface.